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A Summary of Current Program 7/1/64
and Preliminary Report of Progress
for 7/1/63 to 6/30/64

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CURRENT SERIAL RECORDS

HUMAN NUTRITION RESEARCH DIVISION
of the
AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE
and related work of the
STATE AGRICULTURAL EXPERIMENT STATIONS

This progress report is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1963, and June 30, 1964. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Human Nutrition Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Maryland.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

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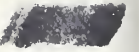


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INTRODUCTION

The research reported here presents recent progress in understanding the nutritional needs of normal man and the manner by which these needs can best be met by food. The research involves studies of the absorption, transport, and metabolism of individual nutrients in the body as related to age, activity, and environmental conditions. Studies of metabolic processes and nutritional requirements in man are preceded, guided, and expedited by results from intensive studies on laboratory animals and lower forms of life in which all factors can be rigidly controlled and physiological responses can be measured during each stage in the life cycle and during successive generations. The research includes the nutritive and other consumer values of foods as measured by chemical or physical means and by biologic response, and the effects of household practices upon the nutritive value and inherent qualities of foods. Applications of the knowledge gained from human nutrition research influences the food habits and nutritional status of man and also market demand and the orientation of agricultural production.

The program is carried on by the Human Nutrition Division of the Agricultural Research Service of the U. S. Department of Agriculture. It is conducted at the Agricultural Research Center near Beltsville, Maryland, and under contract and cooperative agreement with universities, medical schools, hospitals, and industry. In addition, the Division collaborates with Regional programs of the State Experiment Stations. The Federal scientific effort devoted to this research in Fiscal Year 1964 totalled 60.5 professional man-years with 57.2 engaged in the program near Beltsville, Maryland, and the equivalent of 3.3 in contract and cooperative agreements. The program is divided among study of: Functions and metabolism of nutrients, 20.8; human metabolism and requirements for nutrients, 5.9; nutrient value of foods, 18.2; and other food qualities and consumer use, 16.6.

Basic information on human nutrition is needed for conservation and optimal utilization of human and food resources in our expanding population. The Division has contributed to this goal by providing information on nutritional and food needs and on the qualities of foods which influence their usefulness to consumers. Some of these contributions have been summarized here:

Influence of diet on tissue changes in the rat with aging. Long-term investigations indicate that diet may be a factor of importance in accelerating degenerative changes in the tissues of the rat. The diets

investigated contained nutrients in amounts currently considered adequate for maintenance. Kidney disease increased with age and was found in animals on all diets, although the onset and severity of the lesions appeared to be accelerated by certain combinations of dietary ingredients. When kidney damage was severe, degenerative changes were found in the heart and arteries which were probably secondary to the kidney disease. These tissue alterations in the cardiovascular system resembled certain types of human vascular disease. Differences in the response to diet could not be explained by level of dietary fat or protein. Further experiments are in progress to determine which factor or combination of factors are associated with the lesions.

Protein requirements and age. The possibility that the protein requirement increases with age may change recommendations given for diets to meet the needs of older individuals, particularly when reduced caloric intake is desired. ARS scientists have found that a low level of protein which proved adequate for maintenance of tissue proteins of young adult rats was inadequate for older animals. The inability of the older animals to maintain weight or protein equilibrium with the lower protein diet may indicate that the amino acid needs differ with age of the animal.

Commercial and home-prepared foods compared. ARS food specialists have compared the composition and preparation time for prepared market forms and home-prepared meat, fish, poultry, and cheese items to provide consumers factual information for decisions on food purchases. Ninety-five food items representing thirty-six different kinds of foods in various forms were included. Formulas used for the home-prepared products were typical of those published for family use.

Commercially canned products differed more from their home-prepared counterparts in total protein, fat, and ash than did frozen or chilled commercial forms. Commercially prepared foods generally had lower fat, protein, and calorie values, and higher ash and carbohydrate contents than the corresponding home-prepared foods. Physical separation of the contents of ready-to-serve food also showed that most of the commercially prepared foods contained less meat, fish, or poultry than comparable foods prepared by family recipes. The content of meat, poultry, or fish in these different kinds of combination foods, including pies and dinners, ranged from under 20 percent in pies to over 40 percent in a main course item of a frozen dinner. Most of the commercial products required less than 10 minutes of active preparation time and were ready for serving in 15 to 35 minutes, compared with 20 to 250 minutes for home-prepared food.

These examples demonstrate how research in the Human Nutrition Division assists and can continue to assist the United States Department of Agriculture in its responsibility for producing enough food and a proper assortment of foods to meet the nutritional needs of the nation's citizens within the general framework of their food habits and for guiding consumers in their selection and use of foods.

AREA NO. 1: FUNCTIONS AND METABOLISM OF NUTRIENTS

Problem. To clarify the functions and metabolic pathways of nutrients much of the nutrition research must be done with laboratory animals and lower forms of life. Only with animals of short lifespan and on controlled diets can both immediate and long-term physiological responses be measured by various biochemical, biological, and histological methods during every stage in the life cycle and during successive generations. Studies of the morphological structure, biochemical composition, and physiological function of organisms, isolated cells, and cell fragments are needed to extend understanding of nutritional processes. The kinds and amounts of nutrients and energy essential for growth and maintenance of body tissues and for nutritional well-being are influenced by such factors as climate, physical activity, and processes associated with reproduction, as well as by the hormone and enzyme activity that reflects heredity, aging, and sources of stress. Both qualitative and quantitative measures are needed of the extent to which these factors influence nutritional needs, metabolic response to various nutrient combinations, and physiological changes within tissues. Results from investigations with laboratory animals, microorganisms, and cells guide research in human nutrition and help to explain metabolic responses to diet.

USDA AND COOPERATIVE PROGRAM

Current investigations are underway with laboratory animals to determine the effects of nutrients and foods on growth, reproduction, and longevity, on the composition of blood and tissue, and on the structure and functioning of tissues at various stages of the life cycle. Chief variables under study are the kinds and amounts of dietary fats and fatty acids, proteins and amino acids, and carbohydrates. Included also are studies of inter-relationships among nutrients when fed in purified form and when supplied from foods. Studies of cellular metabolism are developing new insights into functions, requirements, and quantitative relationships of nutrients important to the nutrition of man.

The program on the functions and metabolism of nutrients is conducted at Beltsville and under contract and cooperative agreement with private laboratories and at universities and medical schools. The studies require staff with specialized training in nutrition, biochemistry, microbiology, histology, and pathology.

The Federal scientific effort devoted to research in this area totals 20.8 professional man-years distributed as follows: Lipids, 11.3; proteins, 3.4; carbohydrates, 3.5; minerals, 1.6; vitamins, 1.0.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

The large portion of the human nutrition work in the States is centered about interrelations involved in metabolism and utilization of amino acids, protein, and lipids. The human and laboratory animals serve as experimental subjects.

Factors affecting amino acid utilization include specific amino acids, peptides, quality and quantity of energy supply (carbohydrates and fats), and vitamins A, B₁₂, folic acid and riboflavin. Investigations of interrelationships include studies of related enzyme and coenzymatic systems. The availability to the human of amino acids of selected foods and of supplemental amino acids is part of this work.

In lipid metabolism, interest focuses on type of nutrient fats, cholesterol formation and break down, and on lipoprotein and phospholipid transport. Other research is concerned with lipid-sulfur amino acids, lipid-vitamin-coenzymes, and lipid-hormone interrelationships.

Minerals under study include calcium, phosphorus and magnesium. The research is most concerned with the role of dietary protein level in calcium utilization, with imbalance of calcium and phosphorus in maintenance of bone structure, and with the role of magnesium in calcium metabolism.

Vitamin investigations include vitamin-vitamin and vitamin-hormone interrelationships and metabolic conversions; e.g., tryptophane to niacin.

There are thirty-nine States with seventy-one projects participating in this program. Thirty-three of these projects contribute to regional projects. The State program in this area involves approximately 58.5 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Lipids

1. Tissue structure. Structural changes in liver and lung of rats were shown to occur with diet even when the diets supplied essential nutrients in amounts considered adequate. Abnormal fat deposits in the liver were found at an early age when the diet fed consisted of 75 percent of a semi-purified diet and 25 percent cooked dried egg. In older rats on this diet, less fat tended to be deposited in the liver but fat emboli were observed frequently in the glomeruli of the kidney. On other diets containing the same level of fat, the liver rarely showed significant structural changes. The incidence of chronic lung disease was relatively high at an early age where the semi-purified diet was fed but was rarely found in the young animal fed the egg containing diet. These data have been prepared for publication.

Research has been initiated to further our knowledge of the structural changes that occur with age and diet in the tissues of the rat. The diets to be investigated include some which promote normal growth and maintenance and others which have previously been shown to produce stress and premature aging. The electron microscope will be used in detecting early tissue changes not seen with the light microscope. BHE and Wistar rats will be used in the hope that evaluation of the tissue changes will help in understanding how and why a stress diet elicits different responses in these two strains of rats.

2. Dietary carbohydrates. Research recently completed has provided further evidence that heredity is an important factor in evaluating the response of the rat to diet. Two strains of rats (BHE and Wistar), previously shown to differ in their ability to metabolize fat, were fed diets identical in all respects except that the diets contained 39 percent sucrose, dextrose, or starch. By 150 days, the level of fat and cholesterol in the livers of BHE rats was high, with the greatest elevation when sucrose was fed. Dietary carbohydrate had little effect on liver fat or cholesterol in Wistar rats. By 350 days, kidneys of BHE rats were enlarged and showed signs of structural changes, this organ still appeared normal in Wistar rats.

The level of cholesterol in the serum of 150 day-old rats was low regardless of strain or kind of dietary carbohydrate. The level of cholesterol was significantly elevated, however, in the serum of 350 day-old BHE rats, with the highest levels in the sera of rats fed sucrose. Serum cholesterol values were also elevated in 350 day-old Wistar rats but to a lesser extent than in BHE rats; no differences related to carbohydrate were seen.

BHE rats fed the sucrose diet had the shortest lifespan; no marked differences in survival were noted among the other groups. Nephrosis, a type of kidney damage, was the cause of death of most BHE rats, and the acceleration of this condition by diet seems to relate most closely to fat deposition in the liver. The cause of death of Wistar rats varied and appeared to be uninfluenced by diet. These findings have been presented at scientific meetings and will be prepared for publication.

In studies on the effect of the kind and amount of dietary fat and carbohydrate on lipid metabolism, conducted with puppies in contract research at Oakland, California, all laboratory work was completed. Results of histological examination of skin biopsies and data on content of different lipid classes and the individual fatty acids in each class of blood serum are being evaluated and prepared for publication. The puppies were fed low-fat diets and diets containing moderate amounts of either corn oil or hydrogenated coconut oil. Each diet was fed with carbohydrate furnished by (a) corn syrup, (b) sucrose, (c) beta lactose, and (d) dextri-maltose.

3. Heated and oxidized fats. Lifetime studies with rats to determine the effect of heat treatment upon the nutritive value of cottonseed oil, lard, corn oil, and hydrogenated vegetable oil, conducted in contract research at Chicago, Illinois, are nearing completion. These fats, when heated more severely than is usual but still comparable to some food preparation practices had increased viscosity, decreased iodine value and linoleic acid content, and increased urea-nonadducting fraction as compared to the unheated fats. Rats fed diets containing the heated fats had a slight but consistent retardation in growth during the first year of life, and a tendency toward increased food intake and decreased food utilization. After two years, the rats fed heated fats seem to be aging at about the same rate as rats fed unheated fats. The few rats still living are being sacrificed as they reach 928 days of age.

In other lifetime studies nearing completion, rats were fed diets containing fresh and mildly oxidized olive and cottonseed oils in contract research in New York City. The last of 140 rats fed these oils died of natural causes at 984 days of age. The rats fed cottonseed oil tended to have higher food consumptions, were heavier, and had higher death rates than those fed olive oil. The rats fed oxidized cottonseed oil had a higher death rate than those fed the fresh oil but the reverse was true for the rats fed olive oil. Neither the type nor treatment of dietary fat was related to the cause of death as determined at autopsy although kidney and heart lesions were more severe for rats fed oxidized cottonseed oil. Analyses of serum and tissues of rats sacrificed at different ages showed (1) only slight differences in cholesterol content of serum, liver, brain, and kidney and these did not appear to be correlated with survival rate, (2) considerably less palmitate in heart and kidney triglycerides for rats fed oxidized versus those fed fresh oils but no significant differences in the overall fatty acid composition of these and other organs, and (3) larger amounts of calcium in the livers but not in the hearts, kidneys, and serum of animals fed oxidized oils and no differences in sodium, magnesium, potassium, and phosphorus content of these tissues. Dietary fat did not affect the size of the heart or kidney at any age. In a second lifetime study under contract at the same location, rats have been fed fresh and mildly oxidized lard and butter oil for 36 weeks. The results given here have been presented at scientific meetings or published.

4. Cholesterol synthesis. The relation of diet to lipid biosynthesis in the rat was investigated. As dietary fat was increased stepwise from 2 percent to 80 percent of calories, cholesterol synthesis increased and fatty acid synthesis decreased as measured by C^{14} acetate incorporation in the livers and carcasses of 3-month-old female rats. Total liver and carcass cholesterol, however, showed no appreciable change. Studies of the effect of feeding a cholesterol-free diet plus inhibitors of cholesterol biosynthesis are nearing completion. Results of analyses showing 75 percent of the total sterols in carcasses of rats fed an inhibitor (20, 25-diazacholesterol) to be desmosterol, were published. When weanling rats were

fed this inhibitor for 3 weeks, desmosterol accounted for 32 percent of brain sterols; when fed the same diet for 6 weeks, desmosterol accounted for 50 percent of brain sterols. No desmosterol could be detected in the brain sterols of controls. Manuscripts presenting these results for publication are in preparation. These studies were carried out in cooperation with the Entomology Research Division. Also in preparation are manuscripts presenting results obtained (1) with rats fed an inhibitor of cholesterol biosynthesis plus cholesterol-free diets containing different amounts of corn oil with and without added cholesterol and (2) with rats fed other inhibitors of cholesterol biosynthesis.

5. Body composition. One of the problems in studying the influence of diet on body composition is the lack of accurate measurements of body composition in the live animal. In order to assess the extent to which body composition at different intervals in the life cycle may be a factor in the long term response of rats to diet, research has been initiated to explore the possibility of applying to small animals such in vivo measurements as K-40 counting for determining lean body mass and cyclopropane uptake for determining body fat.

B. Proteins

1. Requirements. Recent research on the protein requirements of the rat has provided evidence suggesting that protein requirements may increase with age. A diet containing wheat gluten at a level which proved adequate for maintenance of tissue proteins in young adult rats was inadequate for older animals despite similar food intakes for the two age groups. These results are interpreted to indicate that requirement of at least one amino acid, possibly lysine, is higher for the older than for the younger adult animal. The possibility that the protein requirement increases with age may present a problem that needs special consideration in planning the diets of older individuals, particularly when reduced caloric intake is desired. These data have been published in the Journal of Gerontology.

2. Utilization. Laboratory work has been completed in contract research at Chicago, Illinois, on the effect of inhibiting the in vivo breakdown of urea on protein utilization. Data on body composition of urease-immunized and nonimmunized rats fed either soybean protein, wheat gluten, or casein are being evaluated to determine whether the increased weight gains that have been reported as the result of immunization represent an increased utilization of proteins of different quality.

Nutritional evaluation of vegetable proteins. Substantial progress continues on PL 480 projects designed to find practical economical sources of supplementary plant proteins, in order to provide staple supplies for refeeding malnourished populations, especially displaced masses, children, and elderly persons. Several of the most promising protein-rich mixtures of foods from vegetable sources reported last year (Israel) have been

analyzed fully for minerals, vitamins, and amino acids, and further studies have been made of their overall protein value using laboratory animals. One product selected for preliminary feeding trials with young children was composed of one-half sesame flour, one-fourth soy flour, and one-fourth chick peas. In the year ahead human metabolic studies will be used to compare this product with similar low cost protein mixtures already in use in other countries (Central America, India, Far East).

Work was started on PL 480 studies in India to find other potential sources of good quality plant proteins for human nutrition in times of famine and dietary emergencies. Protein concentrates (40 - 60% protein) have been prepared from several types of easily extractable green leaves and their amino acid patterns determined. In the year ahead protein evaluation will be made using laboratory animals.

3. Serine synthesis. Because Leuconostoc mesenteroides, like animals, is able to synthesize the amino acid serine, studies with this organism were conducted to provide basic information on potential pathways of, and the role of folates in serine biosynthesis in animals. Serine synthesis was shown to proceed by the condensation of glycine and a single carbon unit. This single carbon transfer can be mediated by tetrahydrofolic acid in vitro although in vivo synthesis of serine may involve the functioning of a derivative of tetrahydrofolic acid containing several additional glutamic acid residues per molecule. In extracts prepared from cells actively synthesizing serine, most of the folic acid activity was present in two main components, each of which was a derivative of tetrahydrofolic acid and is conjugated with several glutamic acid residues. One of these major "folates" has been identified as N¹⁰-formyltetrahydropteroyltriglutamic acid. These results have been published.

C. Vitamins

1. Thiamine. The effect upon reproductive performance of a chronic thiamine deficiency from weaning until mating has been investigated using female rats of the Wistar strain. Prior to pregnancy the rats were maintained on a basal diet containing either an adequate or a low level of thiamine. During pregnancy the rats were fed an adequate basal diet, or the same diet except that all vitamin levels were doubled. Fewer young were produced by animals fed the low level of thiamine prior to pregnancy than when the level of thiamine was adequate. Albumin and gamma globulin were the only serum proteins that appeared to be influenced by thiamine intake. In other respects reproductive performance and maternal biochemical response were normal even when food intake and thiamine level were low prior to pregnancy. The young were of normal weight. Total serum protein, hemoglobin, and hematocrit were similar. Doubling the intake of thiamine and other vitamins during pregnancy had no effect on reproductive performance. Thiamine content in the young and in livers of mothers was related to thiamine intake during pregnancy and was not influenced by low

thiamine level prior to pregnancy. A manuscript has been prepared for publication.

2. Ascorbic acid. Basic research under PL 480 (India) on ascorbic acid metabolism and requirement is designed to determine the effect of diet on the role of ascorbic acid in animals requiring dietary vitamin C (guinea pigs) and in animals able to synthesize their own (rats). Investigations during the first year with vitamin C-deprived guinea pigs revealed lowered activity of liver enzymes involved in electron transport, and confirmed earlier observations on lowered activity of liver enzymes involved in oxidation. The new observations add to other growing evidence that ascorbic acid aids the metabolism of copper, iron, and perhaps other minerals. In another phase of the study it was found that the very high brain content of ascorbic acid in one type of bird (bulbul) was reduced markedly to one-tenth normal, as compared to one-third normal in liver and about one-fourth the normal in kidney tissue when the bird was deprived of dietary ascorbic acid. The nature of ascorbic acid participation in brain metabolism has not been investigated.

D. Carbohydrates

1. Heredity. Recent investigations indicate that measurement of certain enzymes in the tissues of the rat may provide an important means of assessing nutritional response to diet and of explaining why individuals differ in response even when fed identical diets. Differences due to diet and heredity were apparent in relatively young, 3-month old rats. Among the enzymes investigated, the liver enzymes most susceptible to diet were glucose-6-phosphate dehydrogenase and aldolase. Alkaline phosphatase seemed particularly susceptible to inherent differences in the two strains of rats (BHE and Wistar) under investigation. The results have been presented at scientific meetings.

To aid in explaining the metabolic response of rats with different inherited characteristics, research has been initiated to investigate the influence of different dietary carbohydrates (sucrose, dextrose, and starch) on the enzymatic activities of the tissues of BHE and Wistar rats.

2. Carbohydrate-nitrogen interrelations. Microbiological studies of carbohydrate-nitrogen relationships may provide the key to understanding of the differences in growth and metabolism in animals that have been associated with type of dietary carbohydrate. In previous studies with the protozoan Tetrahymena pyriformis, better growth was obtained when carbohydrate was supplied as a polysaccharide rather than as glucose in a completely defined and balanced medium. Recent investigations have shown that amino acid imbalance may reverse this carbohydrate response. Growth was inhibited by high levels of serine in media with carbohydrate supplied as dextrin, but this inhibition was reversed by glucose, either alone or in the presence of dextrin. Increasing levels of serine resulted in growth

inhibition that was completely reversible by arginine in an apparently competitive manner. In cells grown in the presence of inhibiting levels of serine, the free amino acid levels of arginine and aspartic acid were decreased while those of leucine, ornithine, and serine were increased. In addition to arginine, aspartic and glutamic acids and alanine were also capable of completely reversing serine inhibition. Thus a growth inhibition which mimicked an amino acid interaction appears to reflect interference by serine in some one or more steps of the glycolytic pathway when that pathway starts from a polysaccharide but not when it starts from glucose. These results are being prepared for publication.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Lipids

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AREA NO. 2: HUMAN METABOLISM AND REQUIREMENTS FOR NUTRIENTS

Problem. Research in human metabolism is conducted to determine the kinds and quantities of foods and nutrients needed by individuals for nutritional well-being, and the factors that influence nutritional needs. Systematic biochemical and physical observations of persons on self-chosen and controlled diets provide information on the use of nutrients in the body in relation to age, activity and environmental conditions; and on the quantities of nutrients and food energy required by persons of different ages, by those accustomed to different food patterns, or living under environmental and nutritional conditions. The absorption, transport, and metabolism of individual nutrients and groups of nutrients are investigated. Results of this research aid not only in defining average human requirements for nutrients and for food but also in establishing the lower and upper limits of nutrients and of food combinations conducive to human well-being. Studies are also made of the nutritional status of individuals. Such information is essential for the optimal utilization of our food resources and to all programs for improving nutrition. Application of such knowledge will influence food habits, nutritional status, market demand, and the orientation of agricultural production.

USDA AND COOPERATIVE PROGRAM

USDA research on human metabolism places major emphasis on determining the quantities of nutrients required by persons of different ages on self-chosen and on controlled diets, on measuring the metabolic behavior of individuals with regard to several nutrients at the same time, and on determining the availability and physiological utilization by man of nutrients from diets. The current program deals particularly with factors affecting the metabolism of fat and protein and with mineral and vitamin requirements. Other studies seek to establish the range in biochemical response among individuals on controlled and self-chosen diets. Measurements are made on intake, output, levels in the blood, and other criteria available in the living organism. Systematic compilation and reevaluation of all available knowledge on subjects of special nutritional significance are made to indicate gaps which should be filled by research, to prevent unnecessary replication of work, and to suggest the most promising areas for new research.

The program is carried out in the laboratories at the Agricultural Research Center through contract and cooperative agreements with universities and medical schools, and through participation in Regional Projects of the State Agricultural Experiment Stations. Nutritionists, biochemists, physiologists, physicians, and statisticians cooperate in the program.

The Federal scientific effort devoted to research in this area totals 5.9 professional man-years distributed as follows: Metabolism, 4.4; requirements, 0.9; food evaluations, 0.6.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

The States are active in research on the relation of nutrition to physiology under normal and experimentally induced stress conditions. This work is chiefly based on the response of laboratory animals. The physiological functions of reproduction, lactation, growth, longevity and well-being define normal states affected by specific nutrient factors. The behavior of selected tissues, as muscle and liver, also define the physiological condition. Environmental and physical stress are introduced in certain work to study the effect of nutrients in off-setting such stresses.

Nutritive entities affecting such conditions include: amino acids, singly and in combination, and in conjunction with varying types of dietary fat; required energy and protein levels and adequacy of protein from natural sources; vitamins in excess and deficiency states; and certain mineral deficiencies. Enzymatic and hormonal changes involved in the experimental alterations are under investigation in many of these researches.

In the area of nutrient requirement and nutritional status the majority of the work involves human subjects. The nutrient balance in preadolescent children is being measured in relation to the determination of the biological utilization of protein from plant sources. This work includes interrelationships among proteins, vitamins, and minerals; micronutrient balance and the basal metabolic rate; and the energy cost of activity.

The nutrient needs of adults under study include energy maintenance and energy expenditure under experimental conditions; protein and amino acids; vitamins, including pantothenic acid, B₆ and ascorbic acid; and selected mineralization factors.

There are twenty-two States with thirty-eight projects participating in this phase of the human nutrition program. Thirteen of these projects are contributing to regional studies. The program involves approximately 31.5 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Metabolism

1. Lipids. A manuscript presenting data obtained in contract research at Galveston, Texas, on the influence of diet on blood serum lipids in pregnant women and newborn infants was accepted for publication in the Journal of

Clinical Nutrition. For 30 women and their newborn infants, no significant correlation was found between the calculated amounts for calories, protein, total fat and saturated, mono and diene fatty acids in the mothers' self-selected intakes in the third trimester and analytical values for cholesterol, total fatty acids, linoleic acid and arachidonic acid in their blood serum or in the serum of their infants. Neither did the serum lipids of the infants show any correlation with those of their mothers. In two- to seven-week old infants, the amount of dietary linoleic acid profoundly influenced serum linoleic acid levels. The relation between individual fatty acids in the blood of mothers and their infants was given in the Multiple Use Report, page 12, for 7/1/60 to 6/30/62.

2. Effect of rate of food intake. The importance of the kinds of diets used as research tools in human metabolic studies has long been recognized. Experience, moreover, has indicated that there is no one basal diet that can be used for all types of metabolic studies. For studies on rate of food intake, a diet in which the nutrients are fed in the same proportion to each other at every meal would be advantageous. Such a uniform diet composed of usual foods was devised and used to investigate metabolic response by human subjects to different rates of food intake as regulated by size and frequency of meals. This diet, consisting of specially formulated muffins, orange juice, butter and jelly, allowed the source of nutrients as well as their proportion to be kept constant in each feeding. It provided about 2,000 Calories per day and adequate amounts of all nutrients known to be required. The diet was well accepted by the subjects and was not unduly monotonous. It is also adaptable for studies on metabolic response of people of different age groups, activities, dietary background and environments. A paper describing the uniform diet has been accepted for publication in the Journal of the American Dietetic Association.

In the above-mentioned study on metabolic response to different rates of food intake, 15 young women 17-21 years of age ate the uniform diet in 3 different regimens. In Regimen 1, the diet was served in 3 equal portions at the usual meal hours. In Regimen 2, 6 equal portions, each one containing half the amount of a portion in Regimen 1, were served each day. In Regimen 3, three portions differing in amount of foods were served at regular meal hours. In this regimen one quarter of the daily food was provided at each of the morning and noon meals and one half of the day's food was served in the evening meal. Each regimen was continued for 20 days with a total of 61 days for the entire feeding period. No statistically significant difference between regimens was found in the nitrogen retention, fat excretion, or in apparent digestibility of fat. Data have been obtained on blood serum levels of lipid components, on the intake and urinary excretion of thiamine and riboflavin and on the intake and excretion of certain minerals. Statistical evaluation of these data has not been completed.

B. Requirements

1. Preadolescent age groups. Few data are available concerning the amounts of nutrients needed by healthy adolescent and preadolescent children to allow for normal growth and development. Cooperation with experiment stations in the Southern Region to investigate metabolic patterns in preadolescent children has continued. Laboratory analyses are complete on intake and outgo of lipids and on levels of major blood serum lipid components (total cholesterol, phospholipids, and triglycerides) for 12 girls, 7 to 9 years of age, maintained on diets with variation in the amount of protein furnished entirely from plant sources. Six girls received a diet calculated to contain about 20 g. of protein per day and six received 37 g.; the diets furnished 71 g. and 88 g. of fat, respectively. The average apparent digestibility of the fat was 90 percent for the girls on the lower protein diet and 88 percent for those on the higher protein diet. Other data are being summarized and a manuscript is being prepared for publication.

Results obtained in cooperative research on metabolic patterns in preadolescent children carried out in 1954, 1956, 1957, and 1958 by seven State Agricultural Experiment Stations in the Southern Region and the Division are being summarized in a Department bulletin at Beltsville, Maryland. A draft of a text to accompany the detailed tabular basic data is nearly completed.

2. Adolescent age groups. To provide information on the nutrient requirements of girls of various age groups, a study of adolescent girls, 16 - 19 years of age is underway under contract at Berrien Springs, Michigan. Their metabolic response to a controlled ovo-lacto-vegetarian type of diet is being measured. Data will be provided for each of 16 girls on nitrogen and mineral balances, on intake and outgo of fat, on blood serum lipid components (total cholesterol, total fatty acids, phospholipids, and triglycerides), and on blood serum riboflavin.

C. Food Evaluation

1. Wheat proteins. A study of the nutritional value of wheat proteins in wheat flour products for maintaining nitrogen equilibrium in healthy adult man is in progress under contract at East Lansing, Michigan. Twelve men served as subjects, 19 - 29 years of age. The dietary protein was chiefly from wheat flour products for a period of 50 days. Criteria to be followed include nitrogen balances, plasma amino acid levels, blood lipid levels, blood urea nitrogen levels, and body composition measurements.

2. Amino acid patterns in food proteins. Statistical analyses of nitrogen-balance data were completed for 35 adults on diets containing the FAO pattern of essential amino acids and the patterns in nonfat milk solids, whole egg, oatmeal, peanut butter, and wheat flour. The data were obtained in contract research at Los Angeles, California; Stillwater, Oklahoma; and Madison, Wisconsin. A manuscript evaluating the integrated data is being prepared.

3. Wheat as rice extender. Research under PL 480 (Hong Kong) has been initiated on the effect on growth and other nutritional indices of children when a significant portion, about 50 percent, of the rice in the diet is replaced with wheat and when their dietary intake of selected nutrients is increased.

Approximately 360 children between the ages of 7 and 16 years are being studied at an orphanage in Hong Kong. Wheat in the form of bulgur is replacing half the amount of rice in the diets of about 180 children and 180 other children are serving as controls on the usual rice diet. A mineral-vitamin supplement and a protein supplement are being given to a portion of each group.

At the beginning of the study in mid-October 1963, and 6 months later, selected anthropometric and biochemical measurements of nutritional status were made of each child. The Navy Medical Research Unit-2 from Taipei, under the command of Captain R. A. Phillips, is making the examinations and these will be repeated in October 1964, at the close of the study. No differences in nutritional status of the children receiving the different staple foods has been evident.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Metabolism

Irwin, M. I., Taylor, D. D., and Feeley, R. M. 1964. Serum lipid levels, fat, nitrogen, and mineral metabolism of young men associated with kind of dietary carbohydrate. Jour. Nutr. 82 (3), pp. 338-342.

Requirements

Sargent, D. W. 1963. Weight-height relationship of young men and women. Jour. Clin. Nutr. 13 (5), pp. 318-325.

AREA NO. 3: NUTRIENT VALUES OF FOODS

Problem. The nutritional value of foods to man represents the combined effects of the proportion and form of nutrients as found in single foods or as combined with others in the ordinary diet. Knowledge of these food components is essential for estimating the dietary contribution of individual foods and the nutritional adequacy of diets of population groups. Analyses of foods by chemical and physical means indicate potential nutritive value and are the basis of food composition tables used by nutritionists and clinicians. Continuing analysis of market-available foods is necessary to keep data on nutrient content current with the adoption of new varieties, and production, processing and marketing practices. Data on both cooked and raw foods are needed to determine the effects of household and institution preparation methods upon the nutrients in foods and to derive realistic figures for nutritive value of diets.

USDA AND COOPERATIVE PROGRAM

Foods, representative of various production sites and practices, processing and marketing procedures, are analyzed as purchased from the market and as prepared for eating by the consumer. Analyses are made for many nutrient components including amino acids, fatty acids, minerals, and vitamins. Values for calorie, protein, and fat content are derived from analyses made of the proximate composition. Methods are developed for newly identified nutrients and forms of nutrients; existing methods for known nutrients are improved and adapted for use with different foods.

The research is conducted at Beltsville, Maryland, and under contract and cooperative agreement in the laboratories of universities, medical schools, and industry. Chemists, biochemists, biologists, and statisticians participate in the program.

The Federal scientific effort devoted to research in this area totals 18.2 professional man-years distributed as follows: Vitamins, 4.3; mineral elements, 2.1; proximate composition, 2.7; lipids, 4.7; proteins and amino acids, 2.3; carbohydrates, 2.1.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Food composition and nutritive value is most frequently related to indigenous agricultural products. Specific and locally grown raw products are being extensively evaluated for essential nutrients, especially in Hawaii and Puerto Rico. Much work is related to changes induced by growing practices, processing and storage.

The form of fats and lipids in food stuffs and the changes involved in processing and holding are receiving special attention as the role of different types of fat in human nutrition unfolds. Protein content and structure continue as active research areas. The importance of entities containing conjugates of protein and lipids is being investigated in relation to nutritive value and characteristics induced by these conjugates in the processing of foods.

Certain raw products are being evaluated for their significant vitamin contribution to nutrition. The effect of production and processing practices on vitamin content continues as an area of interest. Additionally, research has been directed toward the study of vitamins in food stuffs as affected by inhibitory and stimulatory factors.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Vitamins

Analyses for the vitamin B₆ content and distribution in cereal foods, fruits, nuts, and cheeses available to and as eaten by consumers are nearly completed. A manuscript giving the data on cereal foods has been prepared and manuscripts on the other food groups are in process. Analyses on meats and vegetables are in progress.

A fluorometric procedure for the determination of pyridoxine as pyridoxal cyanohydrin was developed. The reactions were quantitatively reproducible over a range in concentration of 1 millimicrogram to 1 microgram per milliliter. Procedures for chemical assay for pyridoxal and pyridoxamine previously had been developed in this laboratory. Present studies are to adapt chemical procedures to analyze food extracts for the three forms of vitamin B₆. The procedures are expected to provide a more constantly reliable method for measuring this vitamin. Values from the chemical procedures are being compared with values obtained by microbiological determinations for vitamin B₆ in foods.

Development of coordinated procedures for B-vitamin analyses continued with emphasis on a rapid, stable chemical method for nicotinic acid.

B. Mineral Elements

Laboratory analyses for mineral element content of 29 fresh and 6 dried fruits were completed and statistical analyses are in progress. Results presently available indicate that sodium as well as aluminum, boron, copper, iron, and manganese occur in minor amounts in fruits. The lowest calcium and magnesium values were found in apples. The mineral element content of the fruits varied within and among production areas. All

mineral elements were not equally affected. Lot-to-lot variation of avocado, blackberries, and fresh apricots was significant for seven of the ten elements analyzed. In tangerines, only sodium content varied significantly. Papayas and limes were uniform in mineral content. A manuscript giving details will be prepared.

C. Proximate Composition

Proximate composition was determined and energy values were calculated for rice-containing foods representing long-grain white, curried, fried, Spanish, rice with cheese, rice with chicken sauce, and rice-wildrice mix in one or more market forms, both as-purchased and ready-to-serve. Cooked rice prepared from regular processed rice contained less moisture and more protein, carbohydrate, and energy value than when prepared from parboiled and precooked rice. Frozen and canned products and curried rice prepared from a dry-pack mix were higher in moisture and lower in energy value, fat, and, in most instances, protein than were their home-prepared counterparts. Spanish rice prepared from dry-pack mixes was higher than home-prepared in content of all nutrients except moisture and fat. Considerable variation among brands was found for precooked rice and dry-pack Spanish rice. A manuscript is being prepared for publication.

Laboratory analyses were completed for proximate composition of lean and fatty tissues of raw and baked hams, pork loins, and other raw pork cuts. Statistical analysis of the data is in progress. Energy values are being calculated. The data will be integrated with data on mineral content of the same cuts.

Work also is in progress to modify existing methods for automatic nitrogen analyses to apply to all types of foods.

D. Lipids

1. Meat and meat products. Studies under contract with the University of Tennessee, on the changes in the fatty acid composition of fat in meats when cooked, are estimated to be about half completed. These studies are on ground beef and pork patties using fatty acid composition of glyceride and phospholipid fractions as determined by gas-liquid chromatography, and infra-red spectra for indications of changes due to heating.

2. Dairy products. Studies of the nutritional value of various components of milk are nearing completion. Data have been obtained on body composition of rats, at 400 days of age, fed diets composed of either (1) dried skim milk and butter oil, or (2) milk protein with various combinations of fat, as butter oil or corn oil, and carbohydrate, as lactose or cornstarch. Other data include cholesterol in serum and liver, lactic dehydrogenase in serum, and an assessment of aorta damage.

E. Proteins and Amino Acids

General. Growth response of Leuconostoc mesenteroides P-60 was greater on oatmeal and peanut butter hydrolysates than on simulated amino acid mixtures, but growth was the same on a lactalbumin hydrolysate and a simulated amino acid mixture. The nutrient in oatmeal affecting growth of the organism was identified as vitamin B₆, and that in peanut butter as niacin. A manuscript presenting these findings has been accepted for publication in the Journal of Nutrition. A second manuscript presenting data on the relation between different forms of vitamin B₆ and total nitrogen required for maximum growth of L. mesenteroides is in preparation. Investigations have been continued on the effect of (1) additional factors in food hydrolysates on the growth of L. mesenteroides and (2) the type of carbohydrate in the basal medium on the amino acids required by this and other microorganisms.

F. Carbohydrates

Research is continuing on improving and applying to various foods methods for analyses of individual sugars. Studies are concerned with extraction procedures, the determination of total and reducing sugars by conventional methods, and glucose and fructose by differential oxidation. Thin layer chromatography has been used for the separation and identification of some individual sugars from fruit and vegetable extracts.

Total and reducing sugars, sucrose, dextrin, and starch content of dry fat-free solids of selected 14-day market basket composite diets of 16- to 19-year old boys were determined. Variations among, and correlation coefficients between, different carbohydrate fractions were calculated. Sucrose content varied more than any other carbohydrate constituent. Variations among other carbohydrate constituents were not considered to be nutritionally important. Inconsistencies among the carbohydrate data were apparent for all constituents. Reducing sugars, sucrose, and starch gave positive correlations with total sugars. Negative correlations were obtained for reducing sugars with sucrose, and for dextrin with total sugars. A manuscript presenting these findings has been prepared for publication.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Vitamins

Camarra, R. T., Polansky, M. M., and Toepfer, E. W. 1963. Pyridoxine determined fluorometrically as pyridoxal cyanide compound. Paper presented at the annual meeting of the Assoc. of Off. Agric. Chemists, Washington, D. C.

Toepfer, E. W., Polansky, M. M., Richardson, L. R., and Wilkes, S. 1963. Comparison of vitamin B₆ values of selected food samples by bioassay and microbiological assay. J. Agric. and Food Chem. 11, pp. 523-525.

Proximate Composition

Murphy, E. W. 1963. Total diet study: B. Nutrient content. The authors M. J. Drutsch, D. Duffy, H. C. Pillsbury, and H. W. Loy, Food and Drug Administration, acknowledged the proximate composition data. J. Assoc. Off. Agric. Chemists 46, pp. 759-776.

Lipids

Hivon, K. J., Hagan, S. N., and Wile, E. B. 1964. Preparation and analysis of some food fats and oils for fatty acid content of gas-liquid chromatography. J. Am. Oil Chemists Soc. 61, pp. 362-366.

Peterson, D. O. and Hagan, S. N. 1964. Technic of unpacking glass columns for gas chromatography. Chemist-Analyst 53, p. 86.

AREA NO. 4: FOOD PROPERTIES RELATED TO QUALITY AND CONSUMER USE

Problem. Food properties are altered by heating, chilling, freezing, aeration, physical manipulation, storage, and other practices which comprise household processes of food handling. The quality characteristics of fruits, vegetables, meats, poultry, dairy products, eggs, fats, flour, and cereals depend upon the chemical composition, physical structure, and biological systems characterizing the raw food and the changes induced by preparation procedures. Relationships should be established between the composition and structure of raw and cooked food and those qualities important to the consumer, including ease of handling, perishability, economy of yield, physical appearance, palatability and nutritive value. Such data are fundamental to developing household and institutional methods of food processing and preparation which permit optimal use of available food supplies and consumption of food for good nutrition.

USDA AND COOPERATIVE PROGRAM

Knowledge of the inherent chemical composition, physical properties, and biological systems in raw and processed foods is obtained to provide basic criteria for determination of those characteristics responsible for palatability and functional behavior of foods during consumer use. Principles are established and improved procedures developed for household food preparation, care, and preservation. The research is carried out along commodity lines such as fruits, vegetables, grain and dairy products, meat, poultry, and eggs. Specialized studies are also made with selected food items for use in the school lunch and other food distribution programs of the Department.

The work is conducted at Beltsville, Maryland, and through contract and cooperative agreement with university laboratories. Food specialists, chemists, histologists, and statisticians cooperate in this program.

The Federal scientific effort devoted to research in this area totals 16.6 professional man-years distributed as follows: Plant products quality, 6.1; animal products quality, 0.9; consumer use, 9.6.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

In this area of food preparation, products are related to quality by some measure or group of measures. In general the quality measures include palatability or sensory tests, bacterial counts or identification, a chemical analysis of some labile factor, or some physical test of texture

and structure. Special measures characterize certain classes of products; i.e., vitamin assays, enzymatic activity, water binding capacity, and changes in structural tissues. Combinations of these are involved in the quality evaluation work reported.

The effect of pre-freezing treatments, as blanch and non-blanch of vegetables on the quality after quick-freeze, is under study. Comparative studies are being carried out on fruits and vegetables processed by freezing, canning and irradiation.

The major research in product development is on the production, processing and storage of beef, pork, lamb, poultry and eggs. Variables which affect the initial product, include feeding regimens, age and breed, are under study. Conditions of processing relate to freezing temperature, storage temperature and time, shelf life, and the effect of light.

The structure of baked products as related to the physical and chemical properties of the starches used and supplementary products involved, as sugars is the subject of on-going basic research in the carbohydrate area. The physical structure of batters and doughs which are frozen is also under study.

Other research includes the quality of meat tenderness as influenced by chronological age, post-mortem aging and in relation to connective tissue. Genetic factors which may be operative in establishing carcass characteristics is being investigated in sheep.

Food preparation research focusing on products for home use include: Heat penetration of meats and baked products and the chemical changes involved; high altitude baking of flour mixes and the effect on final product of type of components as hydrogenated fat or oils; microwave preparation of meats, fruits and vegetables, including the chemical alterations involved; and flavor characterization in frozen and stored products by means of vapor component identification.

Many of these same factors are under study in institutional preparation where the quantities involved impose special conditions. Heat penetration and internal temperature as related to quality, yield and culinary quality is an area of intensive study.

The portion of the program reported here includes fifty-two projects in twenty-one States and is comprised of approximately 50.1 professional man years. This is a partial report of the State Experiment Station programs in food science and includes work undertaken by home economics departments. For research on food and fiber utilization see reports of the Utilization Research and Development Divisions.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Plant Products Quality

1. Organic acids, carbohydrates, and fruit quality. Research has been completed relating changes in composition and eating quality occurring as the result of home freezing of strawberries, raspberries, peaches, and cantaloups grown in 1961, 1962, and 1963, to variety and degrees of ripeness. Determinations included soluble solids, titratable acidity, pH, fructose, glucose, sucrose, citric acid, malic acid, quinic acid, total pectin, protopectin, water soluble pectin, shear force, color difference meter readings, and panel evaluation of color, texture, and flavor. Determinations were made both on the fresh fruit and on fruit frozen and stored at -10 to 15° F. for six months. Data are being evaluated and reports of the research are being written.

2. Constituents in cells and cell walls of fruits related to texture. Research was initiated to obtain microscopic and histochemical information concerning the constituents of cells and cell walls in fresh and frozen fruits and their possible influence on texture of fruit varieties. Greater knowledge of minor constituents, such as lipids and proteins, and their relation to major polysaccharide constituents would lead to more informed selection of varieties and improvement in methods for freezing to retain a firm, yet tender texture of the fruit.

B. Animal Products Quality

1. Heating procedures and eating quality of turkey. Research on the rate of heat penetration during roasting of stuffed turkeys and the quality and yield characteristics of the cooked meat has continued to provide a basis for standardizing procedures for consumer use. The eating qualities were generally good when turkeys were roasted at 325° F. to an endpoint temperature of 195° F. in the breast or 185° F. in the thigh. Covering the turkey breast with aluminum foil helped equalize the cooking rates of the breast and thigh meat.

Heat penetration into the stuffing was adequate to assure destruction of food spoilage organisms in turkeys roasted to 195° F. in the breast or 185° F. in the thigh providing the turkeys were held for 20 minutes after removal from the oven to attain their maximum internal temperature.

Yield of cooked, edible meat excluding skin was about 45 percent of the weight of ready-to-cook, unstuffed turkey. A report of these findings has been prepared for publication.

Research on the microbial and quality characteristics of turkeys stuffed and roasted under different conditions is in progress under contract in Indiana. Data on rate of heat penetration in stuffed turkeys roasted at

200°, 325°, and 450° F., with records of weight losses and quality characteristics, have been obtained. Work is in progress on microbial survival during cooking and cooling in stuffing previously inoculated with Staphylococcus aureus and vegetative and spore forms of Clostridium perfringens.

Studies were completed on eating quality and yield of light meat and dark meat turkey rolls roasted at 250°, 325°, and 400° F. to endpoint temperatures ranging from 161° to 212° F. Manuscripts presenting data from this research are being prepared for publication.

2. Quality of fresh and cured pork roasts. Flavor, tenderness, and juiciness of fresh pork rib roasts as determined by a taste panel were not associated with original backfat thickness of the hog carcasses. Juiciness tended to increase with increase in marbling of the lean. Total cooking losses averaged 21 percent (6 percent as drippings and 15 percent as evaporation). This information was obtained under contract in Iowa and is based on evaluation of the right and left loins from 48 pork carcasses differing from 1.0 to 2.3 inches in backfat thickness.

Quick-cured hams containing different amounts of curing pickle were evaluated by a laboratory panel and by consumer panels in four cities. Four groups of cured hams, averaging 93, 100, 108, and 117 percent of the weights of fresh hams, were roasted at 325° F. to an internal temperature of 160° F. The laboratory panel rated the hams in the 108 and 117 percent groups more tender and juicy and better in flavor than hams in the 100 percent group. Comments that some hams in the 117 percent group were too juicy or too mild in flavor were made by some panel members. Preferences of the consumer panels were about equally divided among the four groups of quick-cured hams. Total cooking losses were slightly lower for hams in the 93 percent group and slightly higher for those in the 117 percent group than for hams in the 100 and 108 percent groups. A manuscript was accepted for publication in the Journal of Home Economics.

3. Freezer and refrigerator storage in households of pork sausage links. Flavor evaluations were completed for home freezer (0°F.) and refrigerator (45°F.) storage studies of pork sausage links made with and without the antioxidants BHA (butylated hydroxyanisole) and BHT (butylated hydroxytoluene). Storage intervals representative of household practice were used. A report is in preparation. This work is cooperative with the Meat Inspection Division.

4. Endpoint temperatures and quality of broiled beefsteaks. Internal temperature to which rib or eye-of-round steaks are heated during broiling had more influence on scores for tenderness, juiciness, and flavor than

factors of marbling of the carcass or fat content of the muscle. As steaks were broiled to higher internal temperatures, they were usually scored less tender, less juicy, and less flavorful. Eye-of-round steaks broiled to an internal temperature of 140° F. were considered by the panel to be medium done rather than rare; those cooked to 160° or 180° F. were considered well done. Rib steaks, on the other hand, were considered rare, medium, and well done when cooked to 140°, 160°, and 180° F., respectively. Research is being initiated to determine the effect of rate and extent of heating by broiling on color changes in beef during cooking.

C. Consumer Use

1. Freezer preservation of meat in the home. A publication on "Freezing Meat and Fish in the Home", was prepared in cooperation with the U. S. Department of Interior. It presents the latest recommendations on freezing techniques, storage time, thawing, and cooking. The bulletin points out that home freezing equipment that freezes food quickly at 0° F. or lower and maintains these temperatures for storage of frozen products is necessary for high-quality frozen food. Too high or constantly changing storage temperatures cause even frozen foods that are properly packaged to lose quality and food value. Illustrations show how to cut and bone beef, pork, and lamb and how to wrap these products for the freezer.
2. Measuring performance of fats in cakes. The effectiveness of physical measurements in indicating differences in consumer eating quality characteristics of white cakes was calculated from data obtained in the study of the performance of fats in preparation of cakes in households. Viscosity of cake batters and shear force measurements of cakes were good methods for assessing performance of fats as illustrated by high correlations with panel scores for tenderness, velvetiness, and evenness of grain of cakes. Volume of cake was also a good measure of performance of fats, whereas compressibility of cake was a rather poor one.
3. Use of agricultural chemicals. The flavor of roasted peanuts from peanuts grown on phorate-treated soil was significantly better than that of peanuts from plots without insecticide treatment. This flavor difference was not apparent in peanut butter made from the two lots of peanuts. The peanuts evaluated were the Virginia Jumbo Runner 56R variety grown at Holland, Virginia. The soil treatment was with two pounds active ingredient per acre phorate (O, O-diethyl-S-(ethylthio)methyl phosphorodithioate, a systemic insecticide).

Palatability evaluations of color, flavor, and texture were made for snap beans grown on untreated plots and on plots treated at the rate of two pounds per acre with Di-Syston (O, O-diethyl-S-2-(ethylthio) ethyl phosphorodithioate) or with phorate (O, O-diethyl-S-(ethylthio)methyl

phosphorodithioate). Snap beans from Di-Syston-treated plots were rated by the panel as significantly more tender than snap beans from untreated plots or phorate-treated plots although no significant differences were found in readings by a shear instrument. Color difference meter readings showed snap beans from Di-Syston-treated plots were significantly darker, greener, and less yellow than snap beans from untreated plots and from phorate-treated plots. Snap beans from phorate-treated plots were significantly lighter in color than beans from the other two treatments and were significantly less green than beans from the untreated plots. No significant differences were found in panel scores for color. Snap beans from phorate-treated soil had significantly more off-flavor than beans from the untreated and Di-Syston-treated soils, but the off-flavor was considered "slight". Comparable samples of snap beans from the 1964 crop are under investigation. A report on the two years' work will be prepared.

The flavor of several varieties of potatoes grown in pentachloronitrobenzene-treated (PCNB) soil was evaluated in relation to the flavor of potatoes grown in untreated soil. No off-flavors were reported when potatoes were grown in soil treated with 12.5 or 25 pounds of active PCNB per acre at North Dakota in 1960. Off-flavors were found for potatoes grown in Maine in 1960 with PCNB treatment of 20 pounds active ingredient per acre, and with 50 pounds active ingredient per acre in Maine and North Dakota in 1959 and in New Jersey in 1961. A manuscript has been prepared.

Rib roasts from beef animals sprayed with Ruelene had more off-flavor than rib cuts from animals sprayed with water. Flavor of ground round, liver, and kidney from Ruelene-treated animals was similar to flavor of corresponding cuts from control animals and was not adversely affected by the treatments. Two Ruelene treatments were evaluated: (1) beef animals sprayed five times with 0.5 percent Ruelene (O-4-tert-butyl-2-chlorophenyl O-methyl methylphosphoramidate) and (2) sprayed once with 0.75 percent Ruelene. Results are to be published in the Journal of Economic Entomology.

4. Food distribution program. Formulas and procedures were developed for using yellow corn grits in large and small quantity food service. Recommendations for use based on this information were made available to the families, schools, and institutions receiving yellow corn grits as part of the USDA food distribution program.

Guidelines for the use of toasted soy grits were developed for a pilot study in selected feeding operations of voluntary agencies in Latin America. This research was conducted in cooperation with AID, U. S. Department of State. The proportion of water to soy grits to use as a cereal was determined for a formula to provide 5 and 25 servings. Other formulas were developed for using soy grits in combination with bulgur wheat, rice, cornmeal, and dry beans. Also provided were serving suggestions and ideas for using soy grits in various food preparations.

An improved hand-mixing method was developed to make a stable, recombined milk beverage from USDA special purchase, nonfat dry milk, butteroil, and water for use by the Food for Peace program. Amounts of milk ranging from one quart to fifteen gallons have been mixed successfully. Stable, recombined milk beverage has been made by using a mixture of the oily fraction and the crystals of butteroil as well as by using only the oily fraction.

Revision of the publication "Quantity Recipes for Type A School Lunches" (PA 631), was completed in cooperation with the Agricultural Marketing Service and the Fish and Wildlife Service, U. S. Department of Interior. This recipe card file provides 324 quantity recipes or variations and other information needed in preparing Type A lunches in schools participating in the National School Lunch Program. Recommendations on preparing, storing, and handling a wide variety of cereal, dairy, fruit, vegetable, meat, and poultry products were updated to take into account recent research findings and technology. New recipes were laboratory tested and taste panel evaluated, and all formulas and serving yields were recalculated in line with the 1964 revision of PA-270, Food Buying Guide for Type A School Lunches.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Plant Products Quality

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Animal Products Quality

Onate, L. U. and Carlin, A. F. 1963. Relation of physical and sensory evaluations of pork loin quality to backfat thickness. Food Technol. 17(11): pp. 123-126, illus. (Contract research with Iowa State University, supported in part by the Human Nutrition Research Division.)

Consumer Use

1963. Freezing meat and fish in the home. Home and Garden Bulletin No. 93, 23 pp., illus. (Animal Husbandry Research Division, Human Nutrition Research Division, and Bureau of Commercial Fisheries, Department of Interior cooperating.)

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1964. Peanut and peanut butter recipes. Human Nutrition Research Division. Home and Garden Bulletin No. 36, 20 pp. (Slight Rev.).
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Line Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work and Line Project: Number	Work and Line Project Titles	Work Locations: During Past Year:	Line Project Incl. in	
			Summary of Progress (Yes-No)	Area and Subheading
HN 1	Nutrients and related substances in foods.			
HN 1-5C (Rev.)	Vitamin B ₆ values in foods.	Beltsville, Md.	Yes	3-A
HN 1-7 (Rev.)	Proximate composition of foods as purchased and as served.	Beltsville, Md.	Yes	3-C
HN 1-13C (Rev.)	Analysis of foods for fatty acid composition.	Beltsville, Md. Knoxville, Tenn.	Yes	3-D-1
HN 1-15	Mineral elements in foods.	Beltsville, Md.	Yes	3-B
HN 1-19	Chemical determinations of B-vitamins in foods.	Beltsville, Md.	Yes	3-A
HN 1-20	Assay and methodological studies of sugars: and the application of these methods to the analysis of selected fruits and vegetables. *	Beltsville, Md.	Yes	3-F
HN 2	Functions of nutrients and their metabolic interrelationships.			
HN 2-1	Diet in relation to premature physical impairment. **	Beltsville, Md.	Yes	1-A-1
HN 2-15	Analysis of records of a rat colony and development of animals for specific experimental purposes.	Beltsville, Md.	Yes	1-A-5
HN 2-17C	Determination of levels of fatty acids and: cholesterol in blood of pregnant and lactating women on self-selected diets.	Galveston, Texas	Yes	2-A-1
HN 2-20 1/	Influence of kind of dietary fat on growth, longevity, and histological changes in tissues of the rat.	Beltsville, Md.	No	
HN 2-21 1/	Influence of kind of dietary fat on the chemistry of the tissue of the rat at different stages of their life cycle.	Beltsville, Md.	No	
HN 2-24	The effect on rat carcass composition of varying proportions of dietary proteins and carbohydrates.	Beltsville, Md.	Yes	1-B-1
HN 2-35	Effect of graded levels of dietary thiamine prior to and during pregnancy on reproduction in the rat.	Beltsville, Md.	Yes	1-C-1
HN 2-36	The influence of diet on the sequence of histological changes in two strains of rats. *	Beltsville, Md.	Yes	1-A-1
HN 2-37	The influence of age and diet on enzyme systems in selected tissues of two strains of rats. *	Beltsville, Md.	Yes	1-D-1,2
HN 2-38	Influence of kind of dietary fat and carbohydrate on the chemistry and histology of the tissues at different stages in the life cycle of the rat. *	Beltsville, Md.	Yes	1-A-2
HN 2-39	Exploratory investigations on the effect of diet on body composition of the rat, as determined in vivo or by carcass analysis. *	Beltsville, Md.	Yes	1-A-5
HN P-1	Pioneering Laboratory for Cellular Metabolism.	Beltsville, Md.	Yes	1-B-3,1-D-2
HN 3	Food quality, preparation, and preservation.			
HN 3-8	Palatability of selected foods and food products exposed to agricultural chemicals in their production, processing: or handling.	Beltsville, Md.	Yes	4-B-3,4-C-3

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Work and Line Project: Number	Work and Line Project Titles	Work Locations During Past Year:	Line Project Incl. in	
			Summary of Progress (Yes-No)	Area and Subheading
HN 3-14C	:Cooking quality, palatability and yield of: : cooked pork as related to physical and : chemical properties of cuts and of : carcasses. **	:Beltsville, Md. : :Ames, Iowa : :Urbana, Ill. :	: Yes : : : : :	: 4-B-2 : : : : :
HN 3-17	:Exploratory study of variation in cooking : : quality of beef from the retail market. :	:Beltsville, Md. :	: Yes :	: 4-B-4 :
HN 3-18	:The range in proportion of basic : commodities feasible for preparation of : good quality baked products. **	:Beltsville, Md. :	: Yes :	: 4-C-2 :
HN 3-19	:Physical, chemical, and eating quality : characteristics of fruits in relation : to household practices.	:Beltsville, Md. :	: Yes :	: 4-A-1 :
HN 3-21C	:Preparation factors influencing the : quality characteristics of cooked : poultry meat.	:Beltsville, Md. : :Lafayette, Ind. :	: Yes : : :	: 4-B-1 : : :
HN 3-22	:Investigations of the constituents in : cells and cell walls of fruits as : related to eating qualities. *	:Beltsville, Md. :	: Yes :	: 4-A-2 :
SL-AMS 2/	:Technical assistance on food and : nutrition problems in the National : School Lunch Program.	:Beltsville, Md. :	: Yes :	: 4-C-4 :
HN 5	:Biological evaluation of foods and diets.	:	:	:
HN 5-1	:Comparative availability of amino acids : in foods as determined with micro- : organisms. **	:Beltsville, Md. :	: Yes :	: 3-E :
HN 5-2C	:Determination of the metabolic response : of human adults to different combinations : of dietary protein and fat. **	:Los Angeles, : : California :	: : : :	: : : :
HN 5-3C	:Lipid metabolism during growth as affected: : by kind and amount of dietary fat and : carbohydrate.	:Lincoln, Nebr. : :Oakland, Calif. :	: No : : Yes :	: : : 1-A-2 :
HN 5-4C	:Nutritional response of rats to diets : containing selected types of heat- : treated and rancidified fats.	:Chicago, Ill. : :New York, N. Y. :	: Yes : : :	: 1-A-3 : : :
HN 5-5C	:Utilization of dietary protein as : affected by <u>in vivo</u> breakdown of urea.	:Chicago, Ill. :	: Yes :	: 1-B-2 :
HN 5-6	:Nutritional value of various components : of milk when fed singly and in : combination to rats.	:Beltsville, Md. :	: Yes :	: 3-D-2 :
HN 5-7	:Further analyses of data from coordinated : studies of the metabolic response of : young men and women to selected patterns : of essential amino acids.	:Beltsville, Md. :	: Yes :	: 2-C-2 :
HN 5-8	:Lipid biosynthesis as a criterion for : assessing the biological value of foods.	:Beltsville, Md. :	: Yes :	: 1-A-4 :
HN 5-9	:Utilization of energy from diets con- : taining purified proteins versus a : simulated mixture of amino acids. *	:Beltsville, Md. :	: No :	: : : :
HN 6	:Human nutritional requirements.	:	:	:
HN 6-1C	:Metabolic response of human adults to : controlled diets containing different : types and amounts of fat.	:University, Ala.: : Fayetteville, Ark.: : Pullman, Wash. :	: No : : : : :	: : : : : :
HN 6-2C	:Metabolic response of human adults to : controlled diets containing different : types of carbohydrate and fat.	:Fayetteville, Ark.:	: No :	: : : :
HN 6-3	:Development of basic nutrition data on : calcium and magnesium metabolism (for : research workers). **	:Beltsville, Md. :	: No :	: : : :

1/ Superseded by HN 2-38.
2/ Supported in part by funds from Agricultural Marketing Service.
3/ In cooperation with Southern Regional Project S-28, revised.
* Initiated during reporting year.
** Discontinued during reporting year.

PL 480 Research Project Check List -- Reporting Year July 1, 1963 to June 30, 1964

Work and Line Project: Number	Work and Line Project Titles	Work Locations: During Past Year:	Line Project Summary of Progress (Yes-No)	Incl. in Area and Subheading
PL 480				
A6-HN-1	:Studies on the nutritive values of protein: : and availability of amino acids to human : subjects on a low protein diet.	:Taipei, Taiwan	: No	:
A6-HN-2	:Nutritional studies on rice and sweet- : potato supplementation for the : improvement of Formosan diet. *	:Taipei, Taiwan	: No	:
A25-HN-1 (FAS)	:Growth and other nutritional responses of : children to increased intakes of : selected nutrients. *	:Hong Kong, China:	: Yes	: 2-C-3
F4-HN-1	:A survey of amino acid content and bio- : logical value of the protein in major : varieties of food crops in Egypt. *	:Cairo, Egypt	: No	:
A7-HN-4	:Metabolism of ascorbic acid.	:Calcutta, India	: Yes	: 1-C-2
A7-HN-5	:Biochemical and nutritional studies of : leaf proteins. *	:Calcutta, India	: Yes	: 1-B-2
A7-HN-6	:Effects of protein malnutrition and of : different food sources of protein on : learning performance. *	:Baroda, India	: No	:
A7-HN-8	:Studies of hormonal regulation of : cholesterol and fat metabolism.	:Calcutta, India	: No	:
A7-HN-10	:Ascorbic acid secretion during lactation.*	:Baroda, India	: No	:
A10-HN-1	:Development and biological evaluation of : protein in mixtures of foods formulated : from vegetable sources.	:Jerusalem, : Israel	: Yes	: 1-B-2
A10-HN-2	:Nutritional studies of carbohydrate- : and fat-induced lipemias. *	:Jerusalem, : Israel	: No	:
A10-HN-3	:Studies on ultrastructural changes : in essential fatty acid deficiency. *	:Jerusalem, : Israel	: No	:
A10-HN-4	:Comparative nutritional evaluation of : protein mixtures from vegetable sources.*	:Jerusalem, : Israel	: No	:
E15-HN-2	:Food additives and lipid metabolism. *	:Milan, Italy	: No	:
A13-HN-1	:The studies of basal metabolism and : energy expenditures of Koreans in : daily life and work. *	:Seoul, Korea	: No	:
A11-HN-1	:Nutritive value of "tempeh". *	:Osaka, Japan	: No	:
E21-HN-1	:Study on availability and mechanism of : carotene and vitamin A utilization : from different dietary sources and : under different experimental conditions.*	:Warsaw, : Poland	: No	:

* Initiated during reporting year.

